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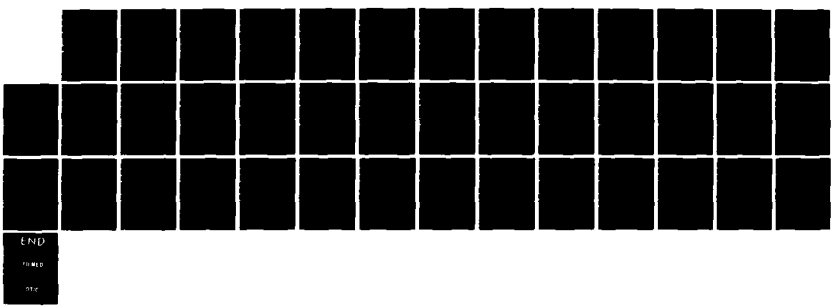

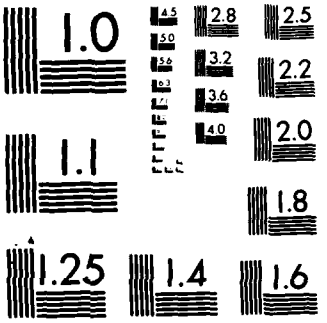

DTIC/TR-85/11 AD-A159 001

Examining Learning Theory of Online Information Retrieval Systems and Applications in Computer-Aided Instruction:

Implications for the Defense Technical Information Center's Computer-Aided Instruction

September 1985

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The Defense Technical Information Center (DTIC) is developing a computer-aided instruction (CAI) tutorial course entitled "Introduction to DROLS Retrieval" in order to train users of its online information retrieval system, the Defense RDT&E Online System (DROLS).

In order to maximize benefits of CAI to DTIC, this paper examined three areas:

1. Learning theory as it relates to online retrieval systems. That is, how do humans learn these systems.
2. Learning theory and its applications to CAI.
3. An advanced draft of DTIC's in-house-developed CAI course entitled "Introduction to DROLS Retrieval" in order to examine CAI instructional design principles.

Recommendations are presented in all three areas.

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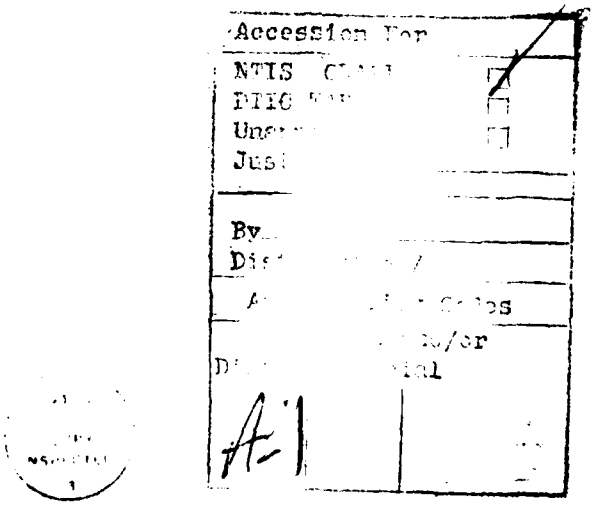

ABSTRACT

The Defense Technical Information Center (DTIC) is developing a Computer-Aided Instructon (CAI) tutorial course entitled, "Introduction to DROLS Retrieval" in order to train users of its online information retrieval system, the Defense RDT&E On-Line System (DROLS). This tutorial, a program of interactive instruction which consists of a dialogue between computer and learner, is intended to serve several functions: 1. It will present an introductory overview of DROLS before new users attend classroom training at DTIC or regional locations. 2. It will provide more experienced DROLS users or users familiar with information retrieval systems with a means to supplement or refresh their knowledge of the DROLS system and its databases.

In order to maximize the benefits of CAI to DTIC, this paper examined three areas:

1. Learning theory as it relates to online information retrieval systems. That is, how do humans learn these systems? Sound instructional methods should be based on a knowledge of how people learn.

2. Learning theory and its applications to CAI. What is known about learning theory and applications to CAI, expecially CAI tutorials, since this is the type of CAI DTIC used in developing its DROLS course.

3. An advanced draft of DTIC'S in-house developed CAI course entitled "Introduction to DROLS Retrieval." Instructional design principles utilized in the design of this course were examined.

Recommendations are presented in all three areas.

INTRODUCTION

One of the missions of the Defense Technical Information Center (DTIC) is to develop and implement a training program for teaching users its online information retrieval system, the Defense RDT&E On-Line System which is commonly referred to as DROLS.[1]

Training presently consists of trainer-guided, small-group instruction sessions comprised of lectures, "hands-on" practice, and explanations of relevant supplementary printed materials. Training may occur at DTIC headquarters in Alexandria, Virginia, or at regional locations convenient to users. Classes are three or five full-day sessions depending upon the terminal classification of the users: Classes for dial-up terminal users are three days; classes for dedicated terminal users are five days.[2]

DROLS Retrieval training for fiscal year 1984 consisted of 240 people receiving dial-up training and 57 receiving dedicated training.[3]

In February 1983, DTIC Project 190.02 was established entitled "Computer-Assisted Instruction (CAI) in DROLS Retrieval." The objectives of this project were to:

A. Provide a capability for presenting and preparing computer-assisted instruction in DROLS retrieval.

B. Develop two prototype courses.

According to Project Leader Richard Thornett, the intent of the CAI project was to serve several functions: 1. It was to present an introductory overview of DROLS before new users attended classroom training at DTIC or regional locations. 2. It was to provide more experience DROLS users or users familiar with information retrieval systems with a means to supplement or refresh their knowledge of the DROLS system and its databases.[4]

The progress of the project thus far has been:

A. Two versions of a PILOT interpreter for presenting the CAI were developed: One runs on the DTIC-ADPE Time Sharing Service hosted by the UNIVAC 1100/61 computer, the other runs on IBM microcomputers and some compatibles. PILOT, a common CAI language, was the authoring software used to write DTIC's CAI.

B. The first prototype course, "Introduction to DROLS Retrieval" (75% completed in-house at DTIC) is currently being improved and completed with the assistance of a contractor. The second course, "Retrieval from the DROLS Technical Report Data Base" will be developed if funding is restored. Under contract terms the contractor is writing instructional objectives for both courses and assisting in completing the first course.[5] This paper will examine only an advanced draft of the DTIC in-house developed version of the course "Introduction to DROLS Retrieval."

PURPOSE OF THIS PAPER

Learning an online information retrieval system, particularly one as complex as DROLS, can be a difficult task-- as online searching "is probably as complex a task as is being assisted by computer today."[6]

Assisting learning processes through CAI should also be approached with caution. As Roblyer points out, in our zeal to use CAI we have been guilty of an uncritical approach to computer use. "The result has been an increase in computer-related activity but with little accompanying progress in determining what works, what doesn't, and why."[7]

It is the overall purpose of this paper to examine how humans learn online information retrieval systems; how DTIC's CAI tutorial can best be utilized in this process; and how DTIC's CAI course, "Introduction to DROL'S Retrieval" can best be designed for this process. The intent of this research is to maximize the benefits of CAI to DTIC, thus saving time and effort which would otherwise be spent in "reinventing the wheel."

The purpose of this paper, then, is threefold:

1. To state present learning theories associated with learning online information retrieval systems.

2. To review learning theory and its applications for DTIC's CAI.

3. To critique the present DTIC in-house developed version of the CAI course "Introduction to DROLS Retrieval" by utilizing and summarizing major principles of CAI instructional design. This critique will recommend areas for possible improvements or modifications. Findings from this critique may be helpful in modifying the present course or developing future CAI courses. Subject matter and content analysis will be deemphasized in favor of examining the instructional design of the CAI itself.

METHODOLOGY

This paper was developed by the following procedures:

1. A literature review was conducted by searching the online databases ERIC and Library and Information Science Abstracts (LISA). The following printed indexes were also examined: Computer Literature Index, Government Reports Announcements and Index, and Library Literature. Other sources or materials recommended through interviews were also examined. The literature review was limited to the last three years in order to focus on current research. This was not an exhaustive, comprehensive literature review due to time and resource restrictions.

2. Interviews were conducted with DTIC personnel and outside sources.

3. DTIC's in-house developed version of the CAI course "Introduction to DROLS Retrieval" was reviewed and examined by using a dial-up terminal in DTIC and accessing this course through the UNIVAC 1100/61 computer. A paper printout of the PILOT program was also examined.

ASSUMPTIONS

For purposes of this paper an online information retrieval system is defined as: A system capable of supporting a human-computer interactive process in which the user is in direct communication (online) with a database and a computer on which it is loaded. Typically, the searcher uses a keyboard to communicate with the computer through a series of typed commands. The computer acts on these commands, retrieving and displaying the data requested usually on a video terminal or a printer device. Results may be manipulated by the searcher so that final results will be printed or displayed in a specified format.[8]

It is assumed that DROLS represents a typical online information retrieval system and that research examining such systems can be studied for useful applications to the DROLS system.

A simplified method for accessing, searching, downloading and post-processing information from DROLS is currently being researched through a federal interagency project called the Defense Gateway Information System (Gateway). This Gateway refers to a concept which would allow a searcher to use one simple command system to access, search, download, and post-process information from a variety of databases of interest to the Department of Defense Research, Development, Test and Evaulation community. Features of the Gateway are presently being evaluated by selected Department of Defense users.

For purposes of this paper it is assumed that full implementation of Gateway features will be a future development. That is, for many years to come there will be a continued need to train users to access and search DROLS. Users may also want to continue to search DROLS directly.

LEARNING THEORIES ASSOCIATED WITH ONLINE INFORMATION RETRIEVAL SYSTEMS

A learning theory can be defined as "the formulation of the laws and conditions of learning."[9] Over the years, the process of learning has been investigated primarily by psychologists seeking to explain how learning occurs. Learning theories usually construct the structure and events (which are generally thought to happen in the central nervous system) which result in the observed behavior known as learning. Theories are usually tested under controlled observations and under a wide variety of conditions.[10]

Learning theories are important because they serve as the basis for instructional theories which, in turn, "identify conditions that will optimize learning."[11] In other words, "designed instruction must be based on knowledge of how human beings learn."[12]

Yet, studies which approach this topic through research in human-computer interaction are very complex and difficult to organize.[13] A number of researchers have written about the complexity of learning online information retrieval systems and the problems involved.

Borgman produced a major review of studies which examined the users of interactive computer systems focusing on psychological theory and method. Psychology was defined for Borgman's review as the study of human behavior--that is, the mental and behavioral characteristics of humans as they interact with computers. Borgman states that most of the research is based on cognitive psychology.[14] This branch of psychology seeks to emphasize how humans internally store and access data.

Borgman reports very little research which applies learning theory to online information retrieval systems. Much of the applied psychological research has tended to concentrate on individual differences, error behavior, and psychological models. Psychological models can be categorized into three types: models of human performance; conceptual models of a system presented to the user by a designer, researcher, or trainer; and mental models of a system formulated by the user.[15]

Bates reports that there is only an elementary understanding of the search process. Furthermore, there is no agreement about how searches should be conducted or the implications of psychological processes in learning online searching.[16]

Meadow views online searching as a complex task which: "(1) Does not follow a well-prescribed sequence of events, (2) is difficult to determine the success of while it is going on, and (3) is highly language dependent."[17] He further states that there is no well-developed theory or model of a search. "Search technique is largely heuristic based on ideas that seem to work but are not formalized into a theory."[18]

Fenichel's analysis of online searching research concludes that experienced searchers were not fully utilizing the capability of online systems and that developing adequate strategies was the problem.[19]

Without a learning theory base, models are usually intuitively developed as ad hoc models of human cognitive processes. These process models help offer a better understanding of how human cognitive processes might function.[20]

There are a number of models of how learning might happen in learning online information retrieval systems. As noted, Borgman's review indicated that models research can be broken into three categories. Some of the models

research is reported here without an attempt to classify it into any of the three categories:

Ingwersen outlines a "cognitive information retrieval model" which explains how searchers interact with an information retrieval system. This model draws on cognitive science (described as a blend of psychology, linguistics, and artificial intelligence) as well as perception, problem solving, learning, and cognition. Yet, how this model translates into instructional theory is not mentioned.[21]

Marcus' model of the search process includes these five elements:

1. Formalized problem representation.
2. Search strategy formulation.
3. Execution of search strategies.
4. Evaluation and estimation measures.
5. Search reformulation.

Each element is further explained and subdivided into its component tasks.[22] Although Marcus' model is designed for an enhanced assistance system which would help users automatically operate and access online information retrieval systems, it seems likely that this model could also be useful in teaching online information retrieval systems, drawing as it does, on human expert intermediaries.

Toliver describes online searching as a mixture of factual knowledge and intuitive skills: There must be a knowledge of the subject area, intellectual and mechanical knowledge of constructing a retrieval strategy, and knowledge of design philosophy and approaches taken by the information retrieval systems. Teaching approaches have usually incorporated rote learning, training courses, manuals, and practice at a terminal.

Huq states that the search process must progress through four stages or phases that must be completed in exact order:

1. Confidence Phase. The user must become familiar with computer operations, computer jargon, and searching terminology.

2. Insight Phase. The user begins to understand how to interact with the computer, and how the information is retrieved. There is also understanding of the form in which information will be presented.

3. Discovery Phase. The user's understanding of the online process is actually applied to real online searches. Concepts such as vocabulary control, search strategy, and system capabilities can be applied to real systems.

4. Negotiation Phase. With an understanding of how the whole process works the user can then transfer concepts to other databases and attempt more elaborate searches.[24]

However, the unpredictability of online searching can cause difficulty to the novice searcher. Virgil suggests that the basic mechanics of searching should be taught as well as specific plans and approaches should the search take a different direction. Thus teaching should include a set of alternate responses to possible search outcomes.[25]

Borgman states that conceptual-based model training seems superior to step-by-step training but not for all types of tasks. This means that training methods which use models of the system provided to the user by trainers, researchers, and designers (conceptual-based models) produce better results by users than teaching methods which rely on procedural or step-by-step instruction without model instruction. However, routine or simple task training does not require model training.[26]

Although models seem a logical and necessary first step, Bates states that even after years of modeling the search process we still do not understand how first-rate searchers achieve their results or how to teach novice searchers.[27]

In summary, learning theory relating to how humans learn online information retrieval systems has not been formalized. Without a formalized learning theory base, ad hoc models are usually developed which seek to depict human cognitive processes. Therefore, models are an attempt to explain how learning might happen.

A number of models seeking to explain how humans learn online information retrieval systems have been developed over the years. Researchers such as Ingwersen, Marcus, Toliver, and Huq have developed models. However, there appears to be no agreement on the "best" model to depict how humans learn online information retrieval systems.

LEARNING THEORY AND COMPUTER-AIDED INSTRUCTION

If a learning theory for online information retrieval systems could be formally developed then the next step could follow: Steps in the learning sequence could be matched with the most appropriate CAI. That is, each type of CAI has a different purpose and, hence, use.[28] The computer is not suitable for all learning outcomes, but it can be effectively used for many learning outcomes.[29]

A number of researchers have identified the various types of computer-aided instruction and the types of skills and practical applications best taught by these types.[30] The three most common types of CAI and applications are:

1. Drill and Practice. A program in which rote information is practiced. The computer presents the student with exercises/problems which the student must perform and solve. Reinforcement is provided. These programs are intended to supplement other instructional methods by teaching basic knowledge. This is the most frequently used and least sophisticated type of CAI.[31] For online instruction, drill and practice CAI can be used to practice knowledge of command language.[32]

2. Tutorial. A program of interactive instruction of new material which consists of a dialogue between computer and learner. Information is presented, questions are asked, responses are given, and feedback is provided. Progress through the lesson can be controlled by student response or computer controlled branching. The types of skills (procedural knowledge perfected through practice) or knowledge (facts and relationships among facts) best taught are: concrete concepts, abstract

concepts, rules and principles and their application, problem solving, and skill modeling. These terms will be defined in the following pages.

3. Simulation. An interactive program which models or imitates a real situation or phenomenom. The student uses the simulation to solve or analyze problems, learn procedures, operate or repair models of complex equipment, control phenomena, and learn actions to take in different situations.

Simulations differ from tutorials. Tutorials present information and guide the student through initial use of the information or skills. Usually this is accomplished through a question-answer format. A simulation, on the other hand, allows the student to actually perform an action in a context similiar to the real situation. Simulations provide feedback of the learner's chosen actions on the problem.

Simulations are most effectively utilized after basic principles and concepts are learned so that meaningful problems can be presented.[33] In online instruction, simulations have been used for representation of real searches, demonstrating search strategies, and allowing user interaction. The major disadvantage is that search strategies must be heuristically developed by only replicating a small part of what a real system would do.[34]

DTIC's Tutorial

DTIC developed its in-house version of the course "Introduction to DROLS Retrieval" using PILOT authoring language software. (A CAI authoring language is a programming language specifically designed to include commands useful for CAI.) PILOT supports a tutorial approach to CAI although the types of CAI are not mutually exclusive. For example PILOT can present simulations such as DROLS responses to user input--that is, a simulation of a DROLS screen. Drill and practice programs can also be included. However, PILOT is best suited for tutorials without the full software capabilities

necessary to create simulations.[35] Because DTIC's CAI supports a tutorial approach to learning, this approach will be examined more carefully.

Tutorials can best be used to teach these knowledges and skills: Concrete concepts, abstract concepts, rules and principles and their applications, problem solving, and skill modeling. These terms are defined as follows:

1. Concrete concepts are some particular class of objects, events, or relations which can be clearly pointed to when defined. For example, birds, chairs, or planes are concrete concepts.

2. Abstract concepts cannot be clearly pointed to but are defined through acquired meaning. For example, justice, peace, and love are abstract concepts.

3. Rules are specific relationships between stimuli usually performed with regularity. For example, the rule for approaching a freeway from an access road states that the driver on the access road shall yield to freeway drivers.

4. Principles are the laws by which a thing operates or the method of a thing's operation. The principle of the conservation of energy is an example.

5. Problem solving is the application of rules or previous learning to an actual or represented problem situtation not previously encountered. For example, "How can oceans be effectively cleaned after oil spills?"

6. Finally, skill modeling is the process of establishing a new skill by presenting essential or selected parts of the skill to be learned.

All of these skills and knowledges are taught by applying established CAI presentation techniques which vary according to the type of skill or knowledge taught. There is a body of research which describes CAI

presentation techniques in more detail. The reader is referred to books by Alessi and Trollip, Steinberg, or Gagne and Briggs for further information. All book titles are mentioned in this paper's selected bibliography.

The following is a greatly simplified outline of the process of incorporating skills and knowledges into CAI:

1. The process begins by analyzing "what" is to be taught (determining course content) and stating in precise terms what is to be taught and under what conditions. This is usually accomplished by the method of writing "instructional objectives."

2. Instructional objectives can be analyzed in order to determine the types of knowledge or skills they represent. Once a determination is made of the type of knowledge or skills to be taught proper CAI presentation techniques can be utilized.

In reality, this is a complicated procedure. In the literature examined for this paper no attempts were found to fully analyze online information retrieval systems by labeling the types of knowledge or skills necessary for the user learning a system. An outside contractor is currently writing instructional objectives for the course "Introduction to DROLS Retrieval." These instructional objectives could be analyzed in order to determine the type of knowledge or skills represented. As mentioned in the third section of this paper (Instructional Design Principles in DTIC's CAI Tutorial) areas of the CAI tutorial design could be based on this analysis.

In summary, the three major types of CAI are Drill and Practice, Tutorials and Simulations. Skills and knowledges to be learned should be matched to the most appropriate type of CAI if effective learning is to be achieved.

INSTRUCTIONAL DESIGN PRINCIPLES IN DTIC'S CAI TUTORIAL

This portion of the paper will examine DTIC's in-house developed version of the CAI tutorial entitled "Introduction to DROLS Retrieval." This course presently consists of sixteen lessons which represent an overview of DROLS, its databases and command language. The course emphasis is on DROLS commands.

Principles of instructional design for CAI tutorials as presented by Alessi and Trollip will be examined. Suggestions for improvements or modifications of DTIC's tutorial will be listed as comments under each principle. The term "instructional design principles" is used here to refer to those factors which affect a CAI program's appearance and its educational quality.

Other factors important to this evaluation should be noted:

1. Subject matter (i.e. actual course content about DROLS) was not evaluated for accuracy or reliability. The intent was to examine the principles of instructional design as they apply to DTIC's CAI tutorial.

2. While all key principles of instructional design as listed by Alessi and Trollip were examined, this evaluation emphasizes those which could contribute to improvements or modifications of the present CAI tutorial or prove helpful in designing future CAI courses. For a full listing of principles of instructional design for CAI tutorials the reader should consult this paper's selected bibliography for books by Steinberg or Alessi and Trollip.

According to Alessi and Trollip, instructional design principles can be applied to several main areas within a CAI tutorial.[36] Seven areas, on the next page, will serve as the outline for this evaluation:

1. Introduction of the Lesson

2. Presentation of Information

3. Questions and Responses

4. Judging Responses

5. Remediation

6. Sequencing Lesson Segments

7. Ending the Tutorial

1. Introduction of the Lesson

a. The title page should include title of lesson, author, date, and possible copyright date.

Comment: Only the title is presented in DTIC's course. The author and date may be added.

b. Objectives or lesson goals should be stated. Objectives usually indicate what the student is expected to learn by the end of the lesson. Objectives may be short statements of expected learning (for example, "In this lesson, you will learn how a lake is formed.") or more elaborate statements called "instructional objectives." Instructional objectives consist of three parts: A statement of the conditions under which the behavior will occur, a description of the behavior, and a criteria for acceptable performance. For example, "When presented with 50 addition problems, the student will correctly solve 40 of them within 20 minutes." Presenting the objectives or instructional objectives usually enhances learning by focusing the student's attention on what is to be learned. Objectives should be stated at the beginning of the lesson.

Comment: The overall goals for the entire course are listed, but objectives for each individual lesson which comprise this course are omitted.

However, instructional objectives are currently being developed for this course by a contractor. Each lesson in DTIC's course is comprised of a section, then a unit. Objectives should be developed at least at the lesson level for students.

c. Directions for entering, exiting, moving through the lesson, and knowing how to enter responses should be clearly stated and available at all times.

Comment: Directions are encountered after the fifth short unit of the CAI course; they should be given earlier, if possible. Help displays could be used to list a summary of user commands(GOTO, STOP, etc.) and directions.

d. Other conditions of the program, its target population and designated implementation, should be stated in the CAI introductory lesson or in accompanying printed material.

Comment: The target population should be clearly identified. DTIC'S CAI course mentions four groups of users who might benefit from the course: Beginning users before a formal DROLS retrieval presentation; searchers experienced in retrieval seeking to learn DROLS; previous DROLS trainees needing refresher training; and managers seeking an overview of DROLS in order to determine possible benefits to their organization.

Because of the amount of detail about DROLS and the length of the course, the present CAI is probably best suited for intermediaries (people who search the system for others) or more advanced end users. Although managers seeking overviews are listed as part of the target population, current research shows that materials should be designed differently for end users than for intermediaries. Overviews for managers should stress:

o Broad conceptual ideas about how information can be used to solve managerial problems (applications orientation).

o Concepts about the system rather than its commands.

o A variety of approaches to gain their attention.[37]

Also, because the course requires several hours to complete and covers so much DROLS content, beginning users might feel overwhelmed. As part of the evaluation process for this CAI course, feedback from beginning users should be assessed. Course content modification, or perhaps a simplified version of the DROLS overview, could be developed specifically for this group of users if feedback warrants this conclusion. Any information about possible future courses, the cost of using the CAI, a phone number for help in solving problems, etc. should also be mentioned.

e. Supplementary materials, if required, should be stated.

Comment: The DTIC CAI course makes reference to other DTIC developed materials such as the DDC Retrieval and Indexing Terminology (DRIT) and the DROLS Diverse Dial-Up Reference Guide. All supplementary materials which are necessary when using this CAI should be listed and supplied.

2. Presentation of Information

a. Modes of presentation should ideally be varied and include, if possible, text, graphics, and sound.

Comment: DTIC's CAI does not include graphics or sound due to hardware/software limitations imposed in order to accomodate the needs of a wider user community.

b. Layouts of material within screen displays should be consistent and attractive.

Comment: This is true throughout most of the lessons. However, the simulation of the DROLS screen should be indicated more strongly. At times the DROLS simulated screen was integrated with the CAI instructions making it difficult to determine when a line of information represented the DROLS

screen or the CAI text. Clearly marking a DROLS simulated screen would help end this confusion.

c. Scrolling should be avoided. This refers to material which does not stay on the screen long enough for the student to read it.

Comment: There are several instances when text scrolls off the screen.

d. Appropriate presentations should be used for presenting concepts, rules and principles, and skills. For instance, research indicates that concepts should be taught by first presenting the relevant characteristics that define the concept followed by examples of that concept. For example, a triangle has three angular sides joined together which total 180 degrees. Next, simple noninstances of the concept are presented. Is a four-sided figure a triangle? More difficult examples of the concept along with more difficult noninstances are then presented. For example, within a grouping of a square, rectangle, and acute triangle, pick out the triangle.

Comment: As stated earlier in this paper, presentation principles are beyond the scope of this paper. Reference should be made to the appropriate books mentioned earlier when formulating presentations for knowledges and skills.

e. Thematic prompts should be used when possible. A thematic prompt is a cue related to the theme or topic of the presentation and is used to guide and give hints to the student. For instance, a prompt for a lesson about ice cream may say "Try again. The answer is an ingredient."

Comment: The prompts are varied throughout DTIC's tutorial. Many offer encouragement or acknowledgement. For example, "Good, let's try another." Thematic prompts are also found. For example, the learner is asked to construct a simple search in the Technical Report File. If an answer is incorrect the prompt says, "Did you begin and end with the @ character?".

In many instances the prompt gives the correct answer. "You forgot the $$$$SON."

f. Jargon should be avoided.

Comment: There are several instances in the tutorial when jargon is used or words are used without being defined.

g. Help screens should be provided. Help screens are usually of two types: procedural and informational. Procedural help refers to help in operating the CAI lesson; informational help refers to assistance with the content being studied.

Comment: Help screens are being planned for the present DTIC CAI course. Two help screens which would be helpful are: A listing of all the user commands (i.e., COMMENT, SHOW, GOTO, TIME, WAIT, and STOP) with a brief definition of each and a listing of all the course lessons which can be quickly viewed without the need to use commands or course numbers.

3. Questions and Responses

a. When possible, questions should test comprehension of material. Questions in tutorials usually follow two forms:

1. Alternate-response questions (i.e., True/False, matching, and multiple choice) in which the student chooses the correct answer from a list. For the CAI author, these questions are harder to write and easier to judge. These questions test recognition of the correct answer.

2. Constructed-response questions (i.e., completion, short-answer, essay) in which the student produces a response. When compared to alternate-response questions these questions are easier to write and harder to judge. These questions primarily test recall of what the proper answer should be.

Testing recall or recognition alone is incomplete. Comprehension, or

testing the understanding of the meaning should be the primary aim of questions. Comprehension can be tested by asking these types of questions:

o Paraphrase. Replace important words with similiar words.

o New Applications. A rule or principle is applied to a new situation. For example, if a rule for ordering documents is discussed a new application might include ordering microfiche.

o Categorical questions. Rules or principles are applied to subordinate or superordinate classes. If a lesson has presented information about photosynthesis in a plant a superordinate question would ask about photosynthesis in the plant kingdom, while a subordinate question would ask about photosynthesis in a simpler plant.

Comment: The present CAI course asks many true/false, and matching questions. While some of the questions test comprehension by applying new applications to previously learned material, more comprehension type questions should be formulated.

b. The response prompt for questions should be below the question, in the left margin.

c. Students should be allowed more than one try to answer a question.

Comment: In DTIC's tutorial most questions allow only one try before the correct answer is given.

d. A correct answer should not be required in order to proceed.

Comment: In several instances the program would not proceed unless a definite correct answer was given.

e. Response formats should give hints to the student about the expected form of response.

Comment: In several instances the expected format of the response was no

clear. If there is a chance of ambiguity, the question followed by the expected form of response in parenthesis should be given. For example:

Which of the following equals 11? (a, b, or c)

a. 5+6

b. 1/2 x 24

c. 5+2+5

f. Questions should appear after or below lesson information on a particular display. Research indicates that questions asked after material presentation facilitate learning of all previous material.

Comment: DTIC's tutorial usually follows this principle, presenting questions after or below material which has been displayed.

4. Judging Responses

Judging response is the process of evaluating an answer or response in order to give feedback to the student.

a. In judging responses, different word order, synonyms, or spelling variations from those expected should be allowed. Correct and expected incorrect answers should be allowed.

Comment: In general, DTIC's tutorial requires a correct answer as determined by the program. Variations in responses, such as synonyms or spelling variations would produce an incorrect answer prompt.

b. The student should be given as much time as desired for responses.

Comment: Five minutes are allowed before a warning message appears if time exceeds that limit. However, time can be extended as necessary.

c. If a student decides not to give a response or is confused, help or a chance to escape should be allowed.

Comment: In the present tutorial there are no help screens and no

established procedures to escape. However, as mentioned earlier help screens are being planned.

5. Remediation

Remediation refers to the presentation of additional information to the student who is not effectively learning. There are usually two remediation techniques: repeating information already seen and restating information in a new or simpler version.

Remediation should be recommended to the student if there is continued poor performance.

Comment: The present DTIC course suggests lessons to be repeated if individual lesson responses are incorrect.

6. Sequencing Lesson Segments

Sequencing lesson segments refers to the order in which the lessons are presented. There are usually two methods of sequencing. In linear sequencing, lessons are presented in a preset, assigned order, and the student must go through lessons in the exact order indicated. In branching sequencing, the sequence may be altered by the student or by student performance.

a. The overall sequence of lessons should be hierarchical or based on the difficulty of the lessons.

b. Branching sequencing should be favored over linear sequencing.

Comment: DTIC's course provides for branching sequencing controlled by the student.

c. Mature students should be allowed to control sequence of the lesson.

Comment: DTIC's course allows students to sequence lessons through the use of a GOTO command.

d. The student should be allowed to abruptly end the lesson.

Comment: DTIC's course allows the student to use the STOP command to end the lesson at any time.

7. Ending the Tutorial

a. The student should know the procedures for temporarily ending a tutorial.

Comment: The beginning lesson in DTIC's course tells the student to note the unit number being studied if the student wishes to stop now but proceed at a later time.

b. A final message should make the end obvious to the student.

Comment: DTIC's course displays a message which signals the end of the course.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations can be formulated for each of the three areas discussed in this paper:

Learning Theories Associated with Online Information Retrieval Systems

Conclusions: Based on the literature review and interviews with researchers in this area, it is concluded that there has been only sparse reasearch in learning theory associated with online information retrieval systems. Because of the absence of learning theory, models of how learning might occur usually develop on an ad hoc basis. Models are one of the methods that can be used for understanding how humans learn.

Recommendations: The practical dilemma remains: If there is a lack of learning theory which serves as the basis for formulating methods of instruction, how should training methods proceed? This question was posed to Borgman during a recent interview in order to formulate recommendations to overcome this problem.[38] Recommendations are as follows:

1. Models, such as those presented in this paper, should be examined. Those which best fit user and system needs should be "borrowed" for use.

2. Models can be developed following user recommendations and system requirements. Trainers, along with more experienced users of the system are ideal candidates to help formulate such learning models. User input was stressed as a very important factor in developing such models.

3. Current research should be monitored for practical applications. Specifically, the author of this paper recommends that DTIC follow a model for learning online information retrieval systems and incorporate CAI within this model. Huq's model, discussed earlier in this paper, is well-suited for this

purpose. As noted earlier, it consists of four phases:

1. The Confidence Phase during which the user must become familiar with computer operations, computer jargon, and searching terminology.

2. The Insight Phase during which the user begins to understand how to interact with the computer and how the information is retrieved. There is also an understanding of the form in which information will be presented.

3. The Discovery Phase during which the user's understanding of the online process is actually applied to real online searches. Concepts such as vocabulary control, search strategy, and system capabilities can be applied to real systems.

4. The Negotiation Phase during which the user understands how the whole systems works and is able to transfer learning to other databases and attempt more elaborate searches.

Depending upon user needs, CAI could be used for phase 1 and 2 while phases 3 and 4 could be approached through the classroom "hands-on" training. Whichever way the CAI is developed, it is strongly recommended that users have input into the CAI development process.

Learning Theory and Computer Aided Instruction

Conclusions: There are three major types of computer aided instruction: drill and practice, tutorial, and simulation. Each type of CAI has a different purpose and, hence, a different use. The type of CAI used should match the appropriate knowledge and skills which are to be taught.

Tutorials best support instruction of concrete concepts, abstract concepts, rules and principles and their applications, problem solving, and skill modeling. Simulations are best used after basic principles and concepts are learned.

The presentation of knowledge and skills by CAI tutorials will vary

according to the type of skill or knowledge to be represented. Course content can be analyzed through a method which requires writing instructional objectives.

Recommendations: It is recommended that DTIC's tutorial approach to online instruction support those types of knowledge and skills identified by the research. That is, a tutorial can best support instruction of concrete concepts, abstract concepts, rules and principles and their application, problem solving, and skill modeling. In order to accomplish this task, the instructional objectives, currently being written by an outside contractor, should be analyzed in order to determine what type of knowledge or skill is represented in the instructional objectives. CAI presentations should then be based on the types of knowledge or skills identified.

Instructional Design Principles in DTIC'S CAI Tutorial

Conclusions: Several researchers have defined principles of instructional design which should be applied to CAI tutorials. This paper evaluated an advanced draft of DTIC's CAI in-house developed version of the course "Introduction to DROLS Retrieval" by examining seven broad areas. It was concluded that some of the instructional design principles could be improved or modified to produce a better CAI tutorial. These conclusions were noted as "Comments" under each of the principles that was discussed.

Recommendations: It is recommended that DTIC examine the modifications and improvements suggested through this evaluation and incorporate those which would be feasible at this stage of project development.

The more important instructional design principles which should be incorporated in DTIC's tutorial include:

1. Objectives or lesson goals should be stated.

2. The target population should be clearly defined and the tutorial should be designed for the defined target population.

3. Help screens should be provided.

4. If a student decides not to give a response or is confused, help should be available or a chance to escape allowed.

5. Supplementary material, if required in the CAI, should be stated.

6. When possible, questions should be constructed to test comprehension of the material.

FOOTNOTES

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